TISA Working Group Update

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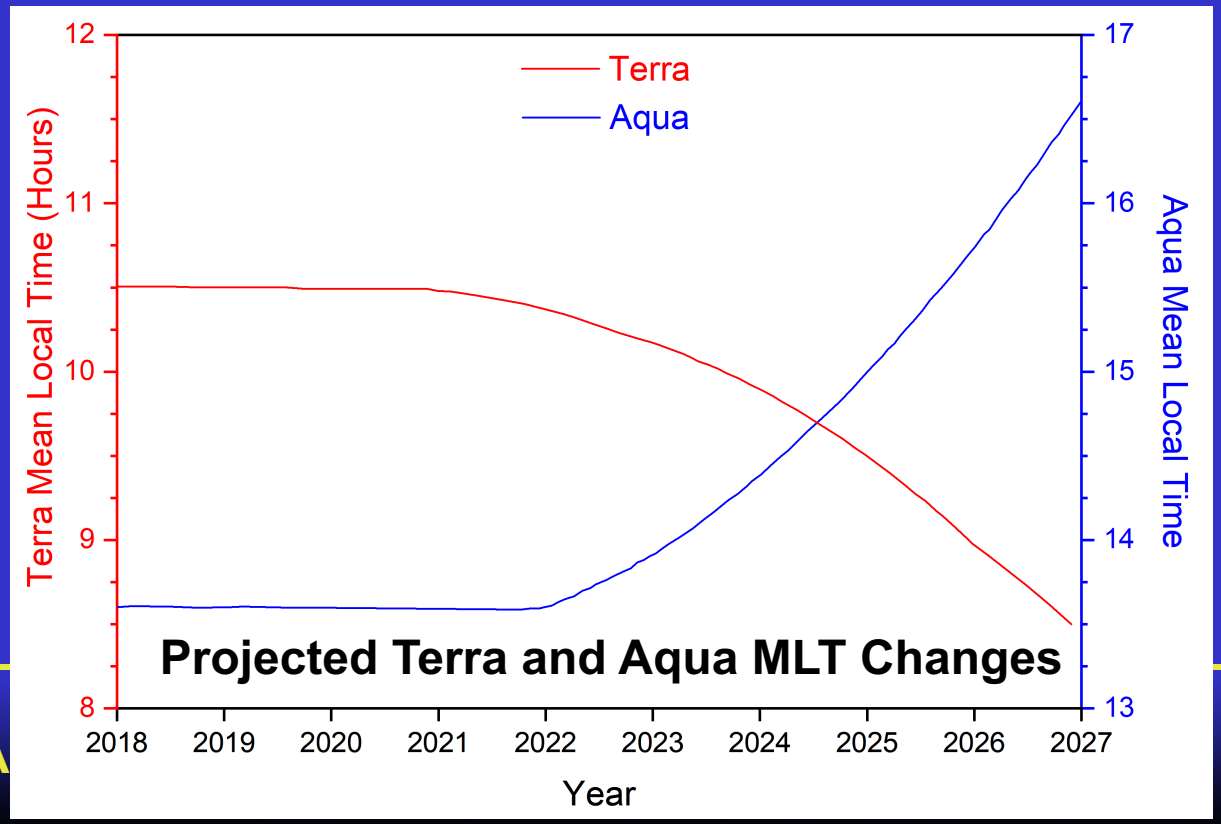
Fall 2022 ERB Workshop (CERES/Libera/GERB/ScaRaB)
Hamburg, Germany, October 12-14, 2022

The impact of drifting orbits on the monthly regional TOA flux assuming constant meteorology based on 15-minute fluxes

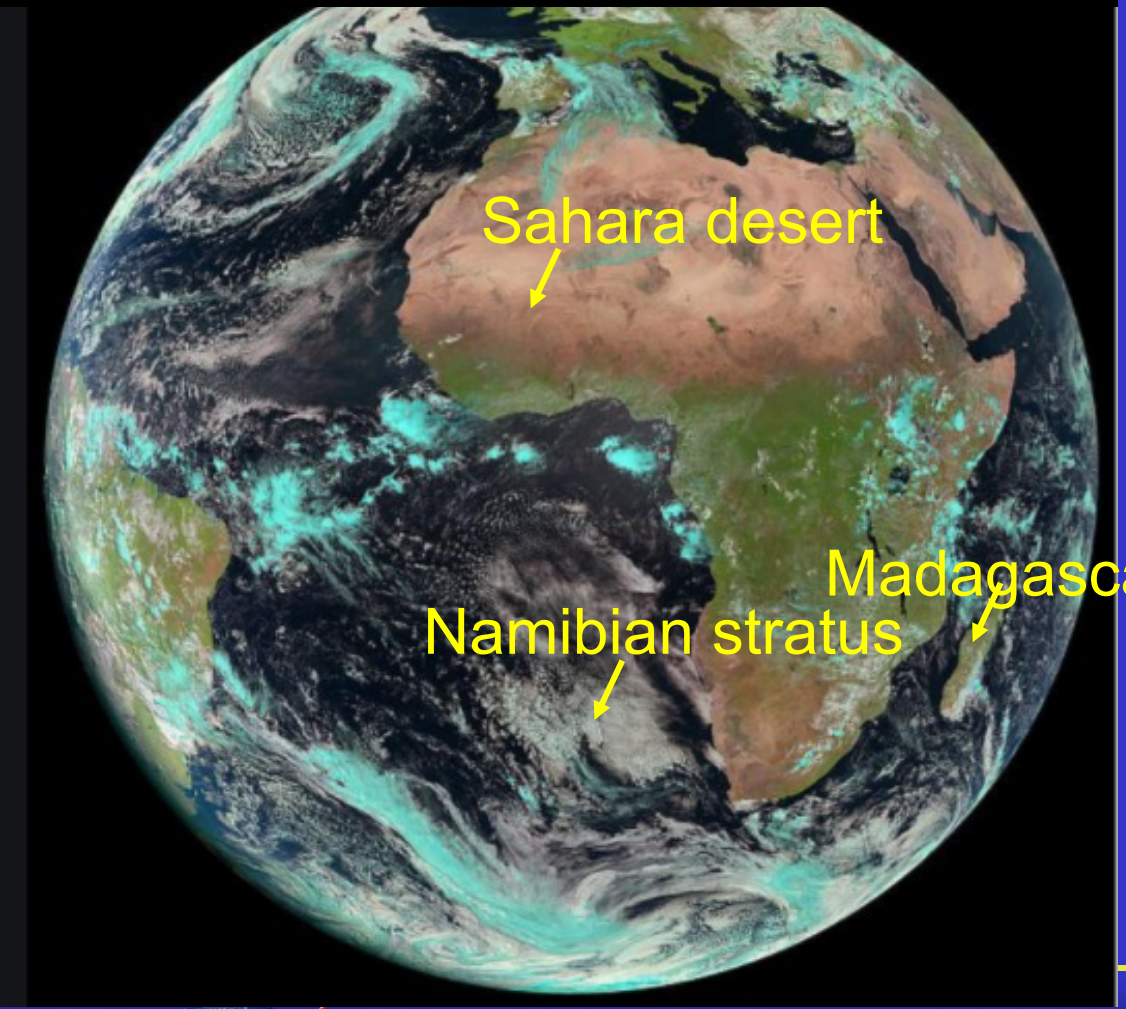
Introduction

- The Terra and Aqua orbits have slowly started to drift in mean local time (MLT) towards the terminator from their fixed 10:30AM and 1:35PM MLTs.
- The MLTs drift will reach 15 min in September 2022 for Terra and mid-2023 for Aqua.
- An MLT drift impacts TOA fluxes derived from individual sun-synchronous satellites because the instruments sample a different part of the diurnal cycle.



Impact of the Mean Local Time drift on CERES SSF1deg products

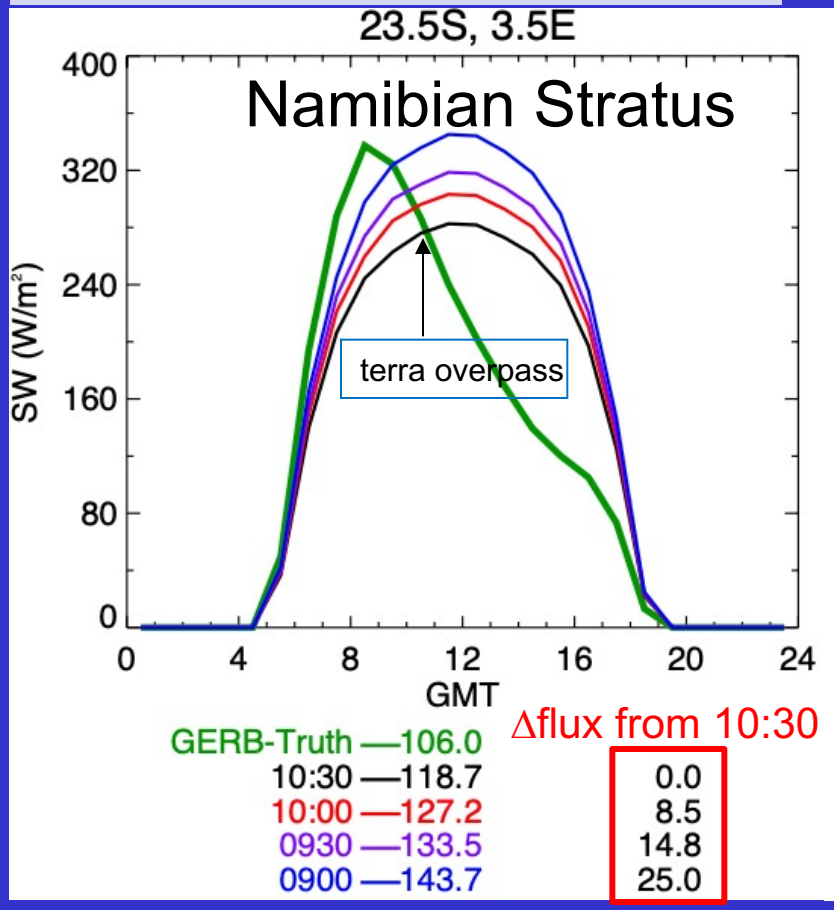
GERB 15-minute broadband fluxes



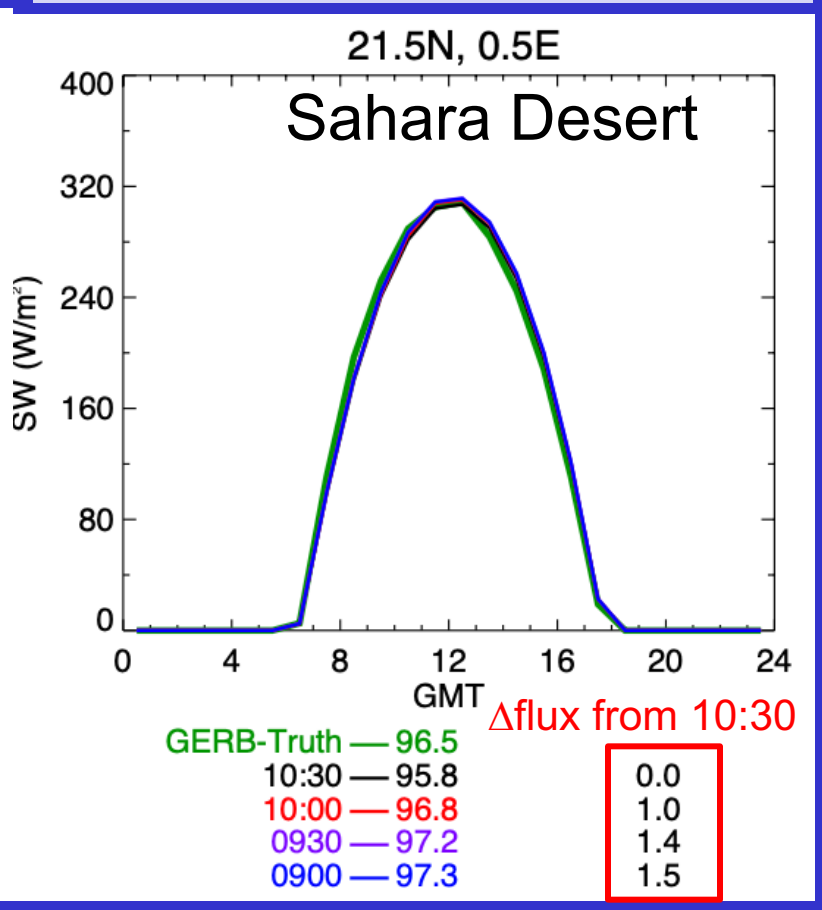
- SSF1deg product temporal interpolation
  - **SW**: Accounts for TOA flux changes throughout the day by assuming the scene observed at the CERES overpass time remains invariant throughout the day.
  - **LW**: Employs linear interpolation between measurement times over ocean and a half-sine fit to take account land heating.
- Approach:
- Use GERB fluxes and clouds as “surrogate” CERES Terra and Aqua data at 10:30AM and 1:30PM and apply CERES SSF1deg diurnal corrections to determine monthly mean fluxes.
- Compare with “CERES-Like” fluxes 15 min, 30 min…, 90 m earlier (Terra) or later (Aqua).
- GERB on Meteosat Second Generation geostationary satellites resolves the diurnal cycle over the Meteosat domain every 15 min.

Monthly Mean SW differences relative to Terra (10:30), January 2010

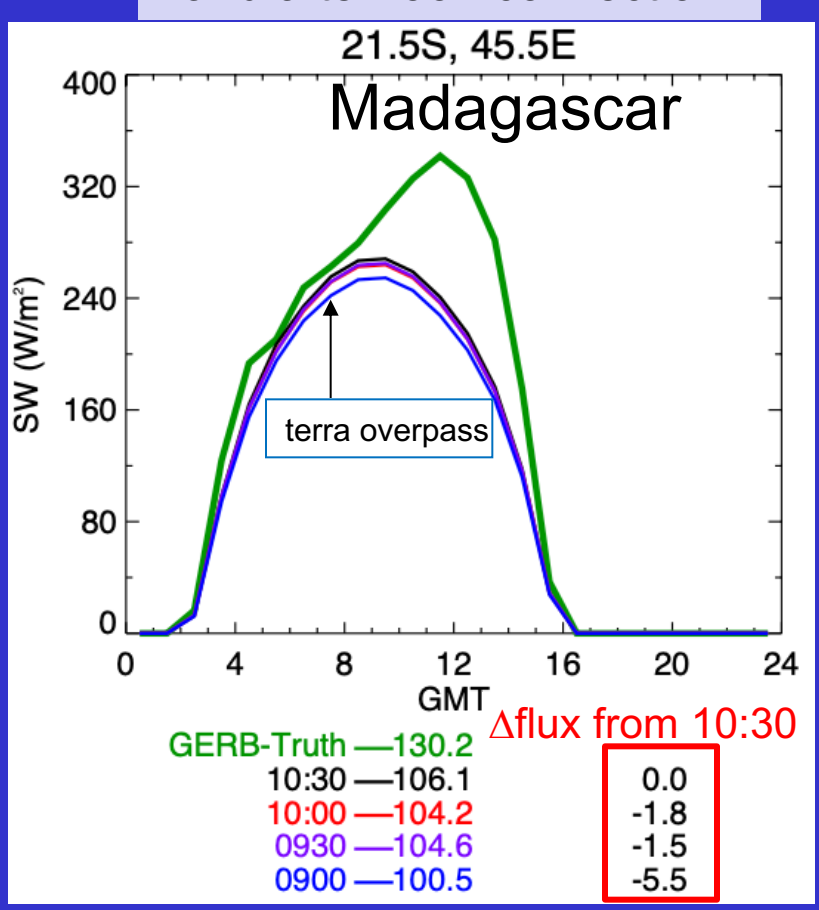
Maritime stratus peaks during morning



clear-sky desert symmetric about noon



Land afternoon convection



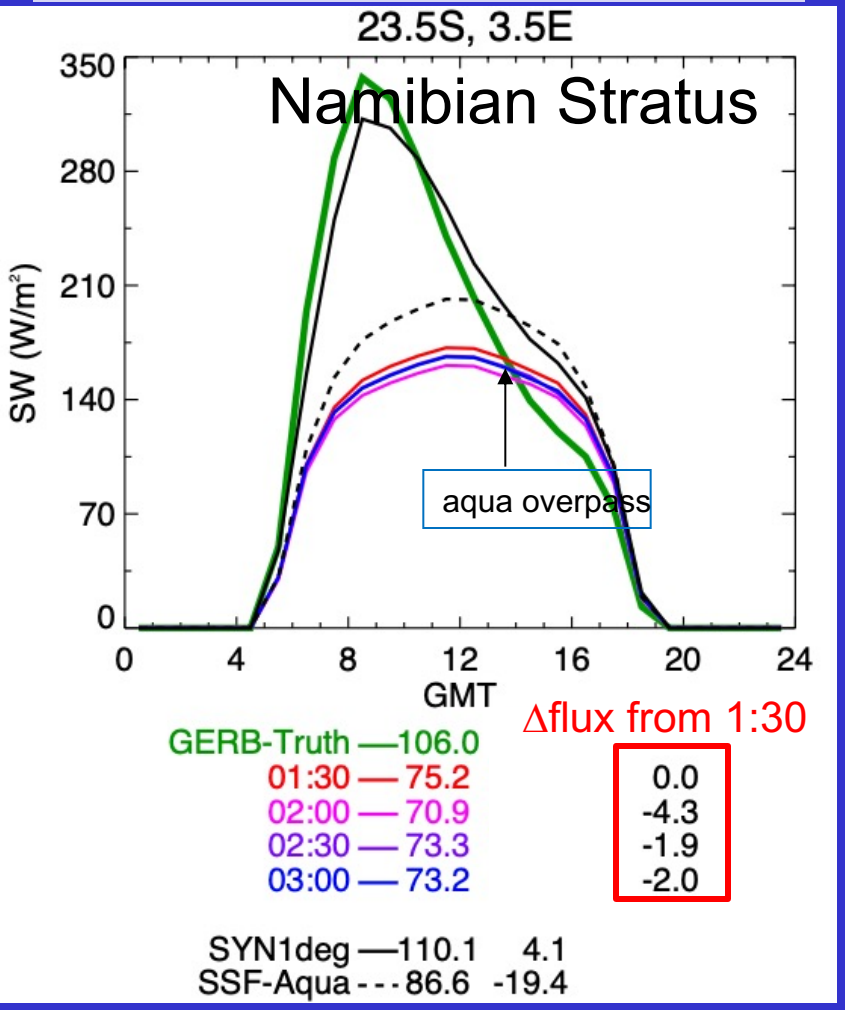
Terra orbit drift will increase the monthly mean SW flux

Terra orbit drift will not impact desert monthly SW fluxes

Terra orbit drift will slightly decrease monthly SW fluxes

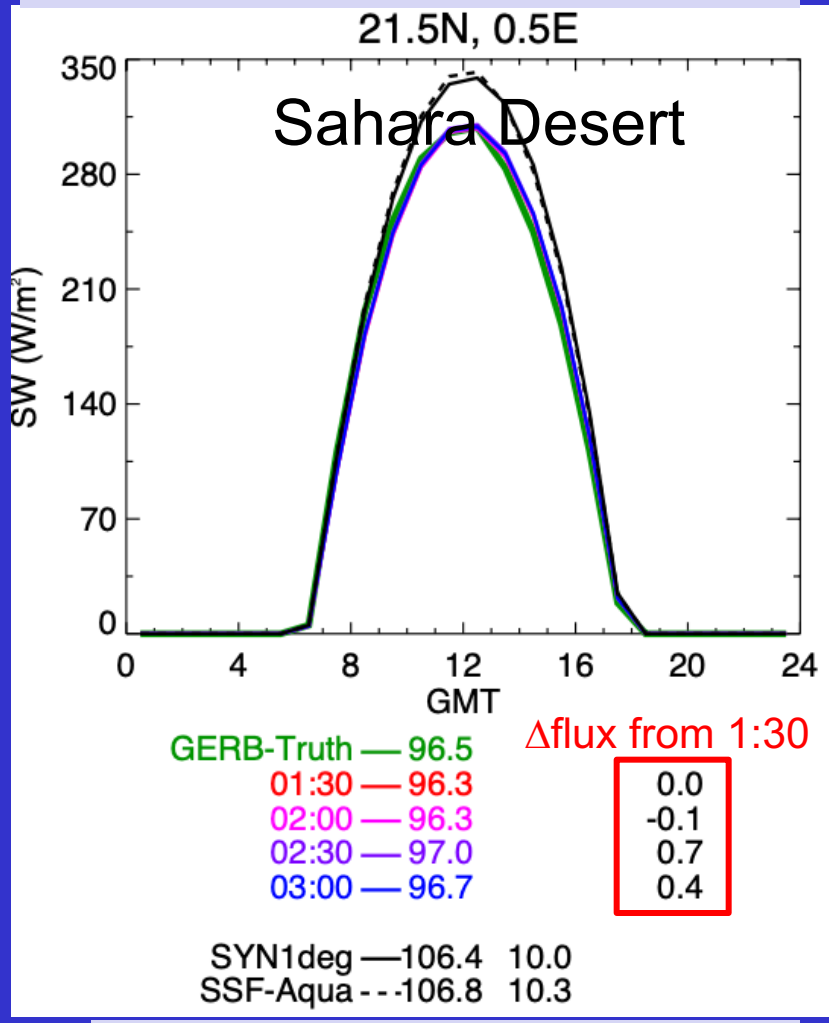
Monthly Mean SW differences relative to Aqua (1:30), January 2010

Maritime stratus peaks during morning



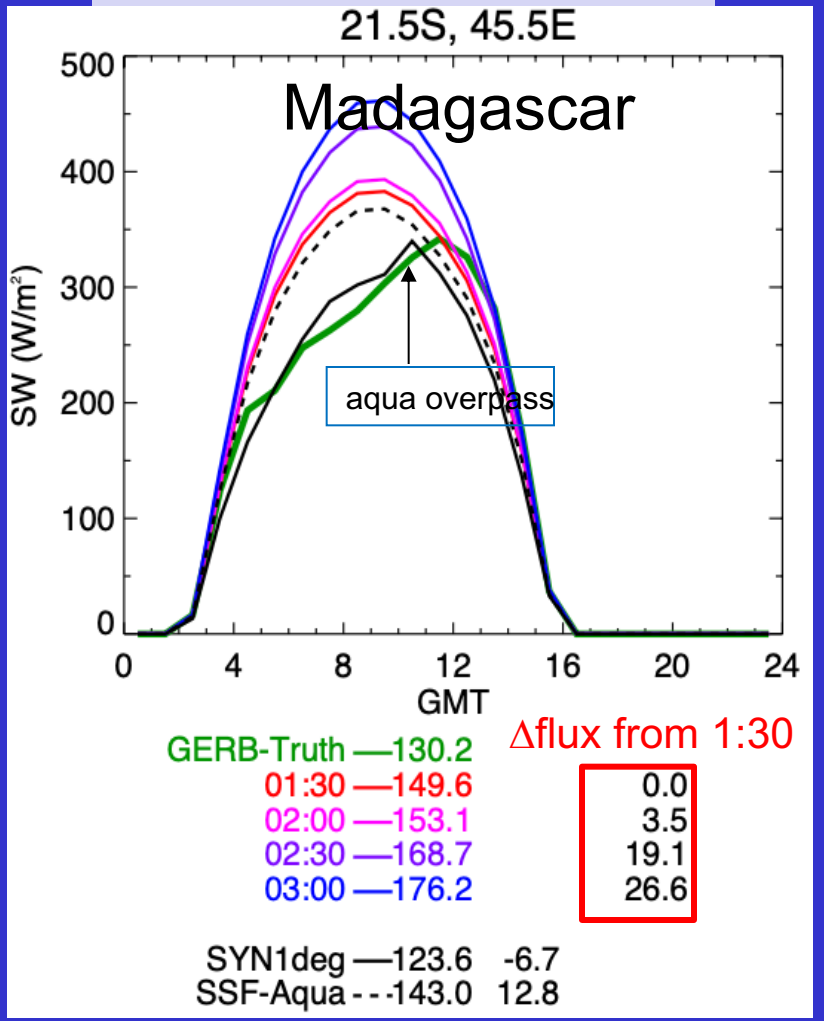
Aqua orbit drift will decrease the monthly SW flux

clear-sky desert symmetric about noon



Aqua orbit drift will not impact desert SW fluxes

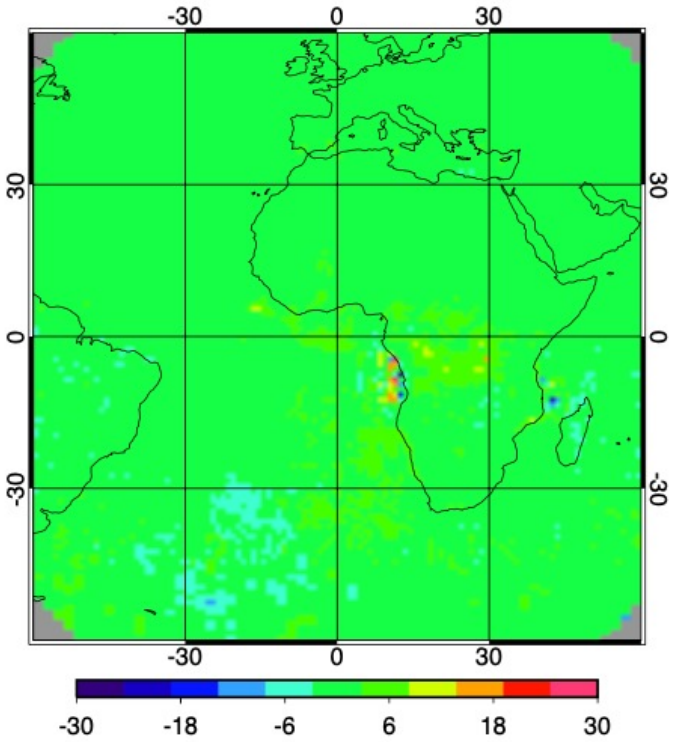
Land afternoon convection



Aqua orbit drift will increase SW fluxes

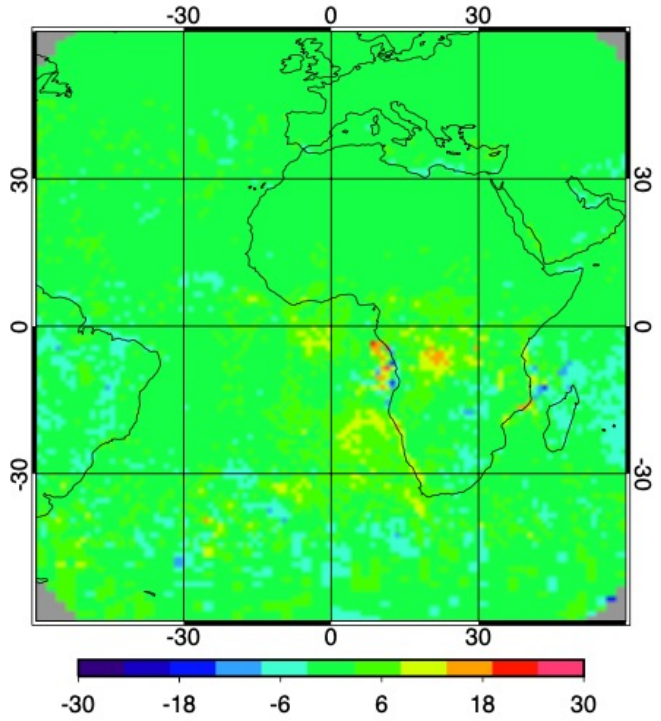
Monthly SW flux difference relative to Terra (10:30), January 2010

10:15-10:30



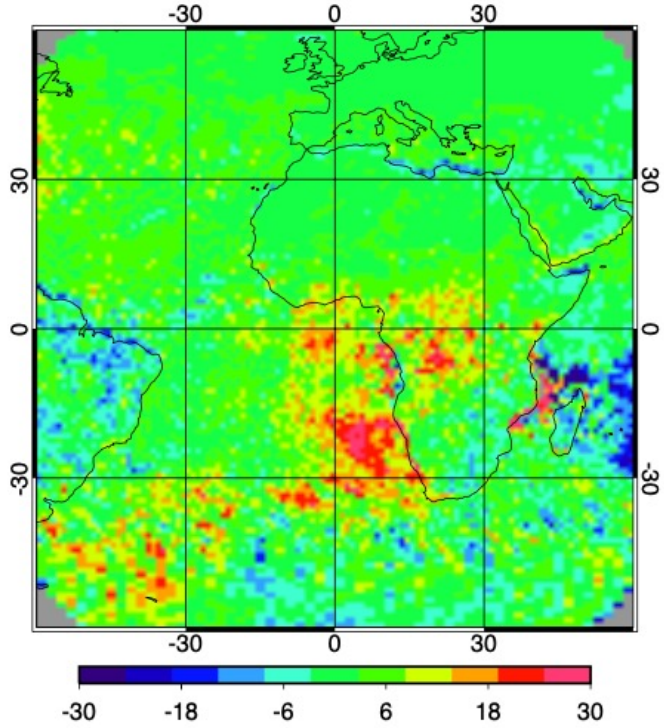
GERB_1015	113.78		
GERB_1030	113.44		
Domain bias	0.34	Domain RMS	1.96

10:00-10:30



GERB_1000	114.24		
GERB_1030	113.44		
Domain bias	0.80	Domain RMS	3.11

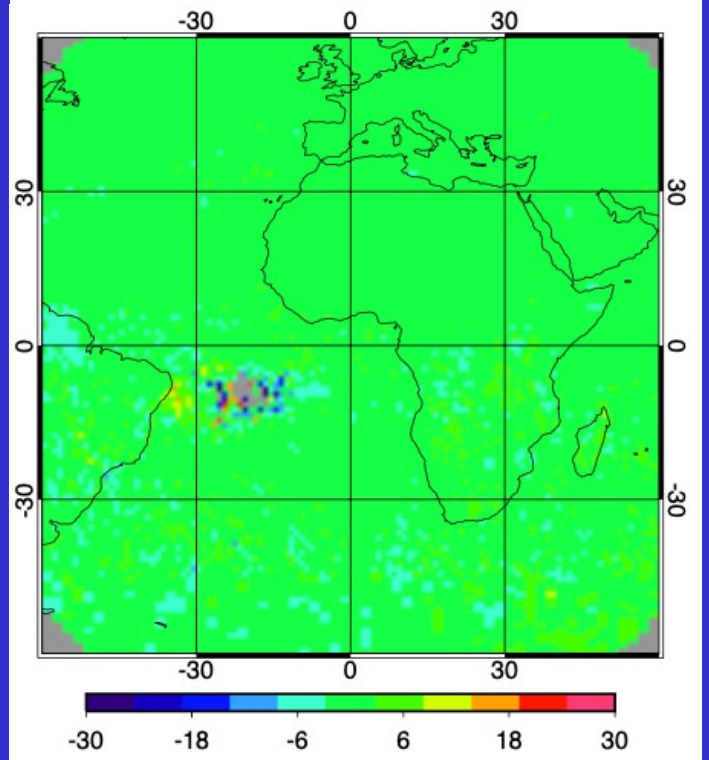
9:00-10:30



GERB_0900	116.25		
GERB_1030	113.44		
Domain bias	2.90	Domain RMS	8.62

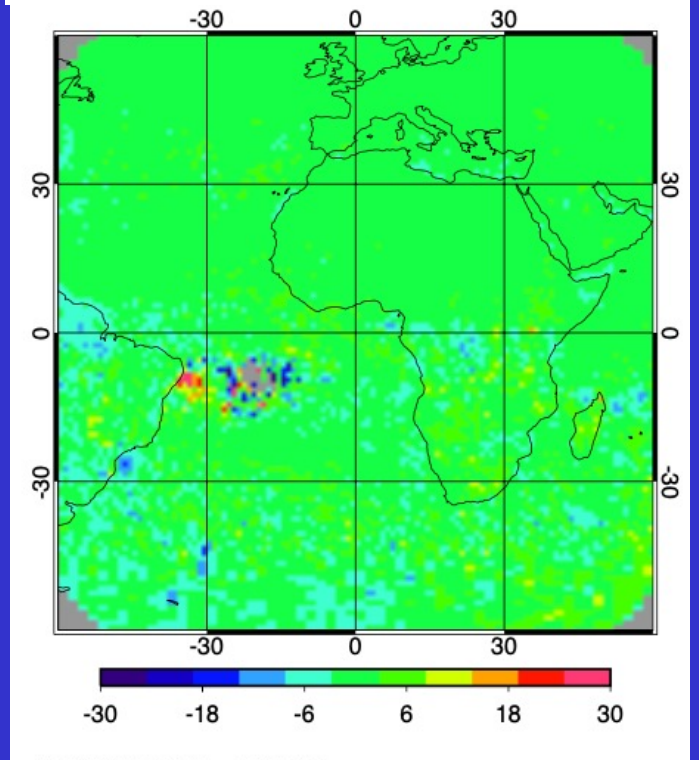
Monthly SW flux difference relative to Aqua (1:30), January 2010

1:45-1:30



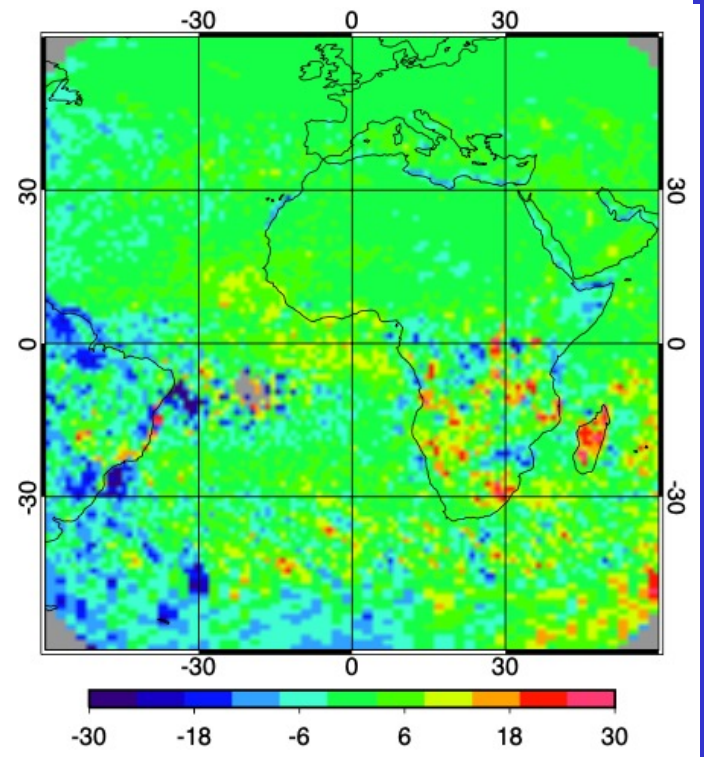
GERB_0145 111.36
GERB_0130 111.30
Domain bias -0.05 Domain RMS 2.33

2:00-1:30



GERB_0200 111.34
GERB_0130 111.30
Domain bias -0.07 Domain RMS 3.36

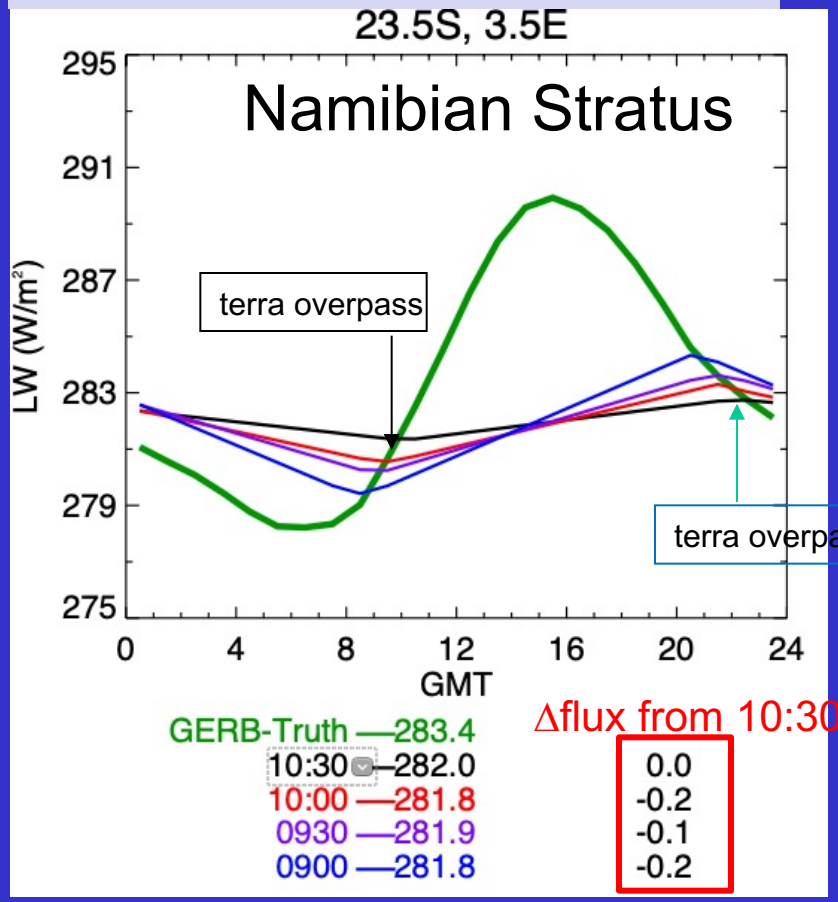
3:00-1:30



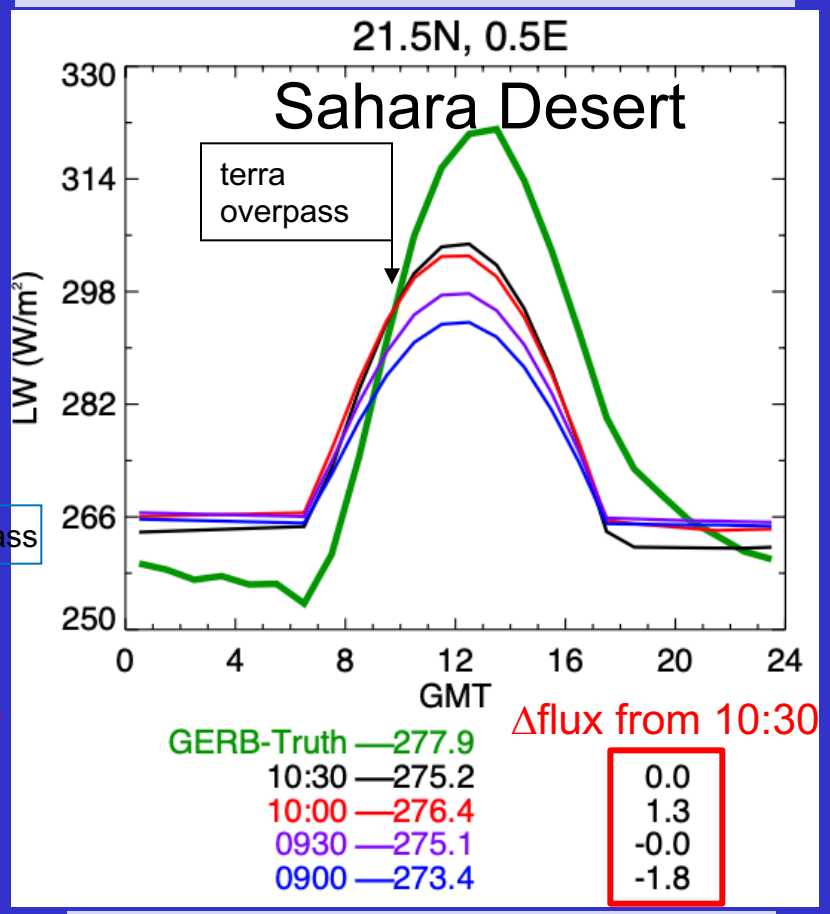
GERB_0300 111.77
GERB_0130 111.30
Domain bias 0.34 Domain RMS 6.97

Monthly Mean LW differences relative to Terra (10:30), January 2010

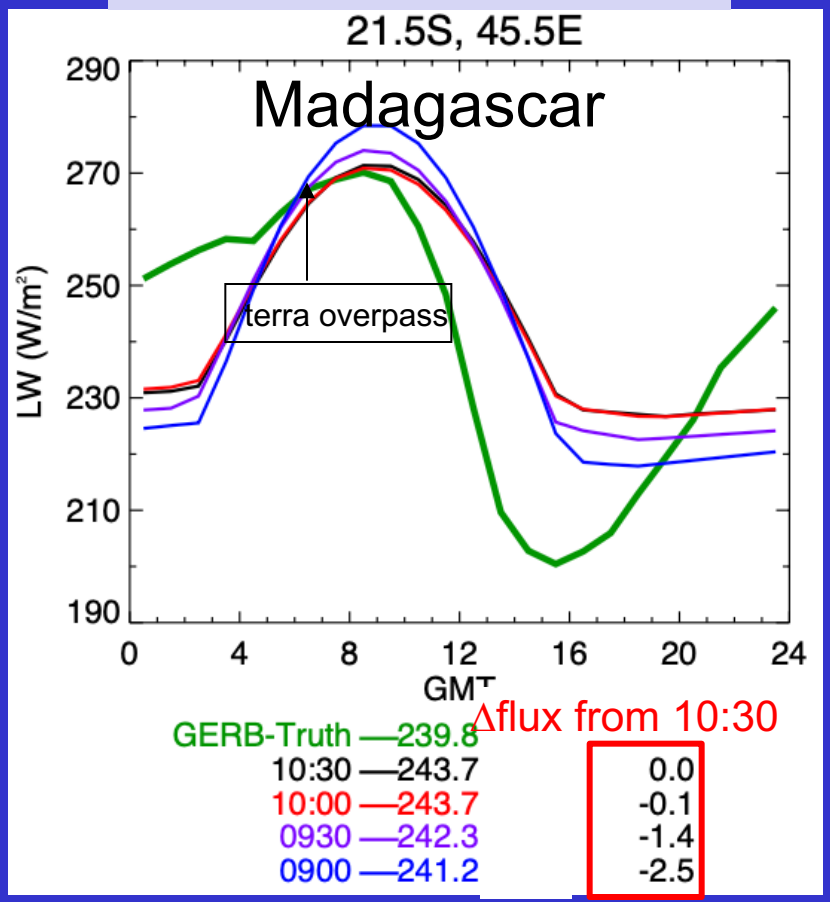
Maritime stratus peaks during morning



clear-sky desert symmetric about noon



Land afternoon convection



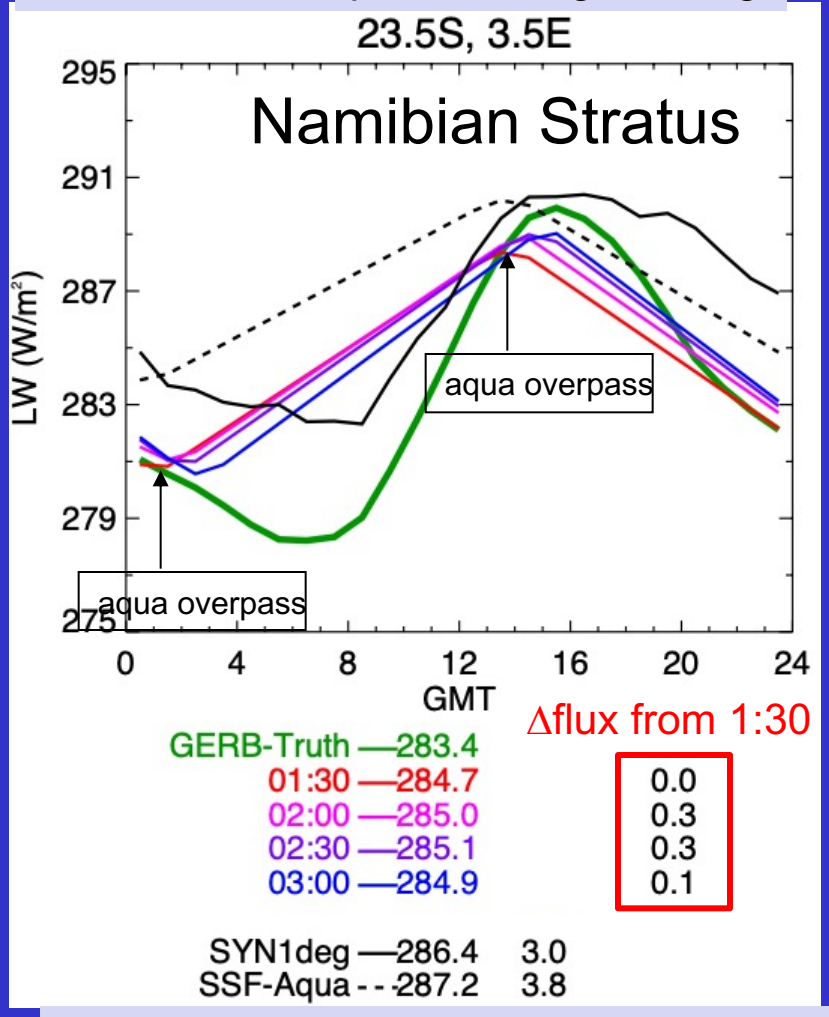
Linear interpolate LW flux observations to compute monthly mean

Employ half sine fit to estimate LW flux due to land heating and a constant nighttime flux

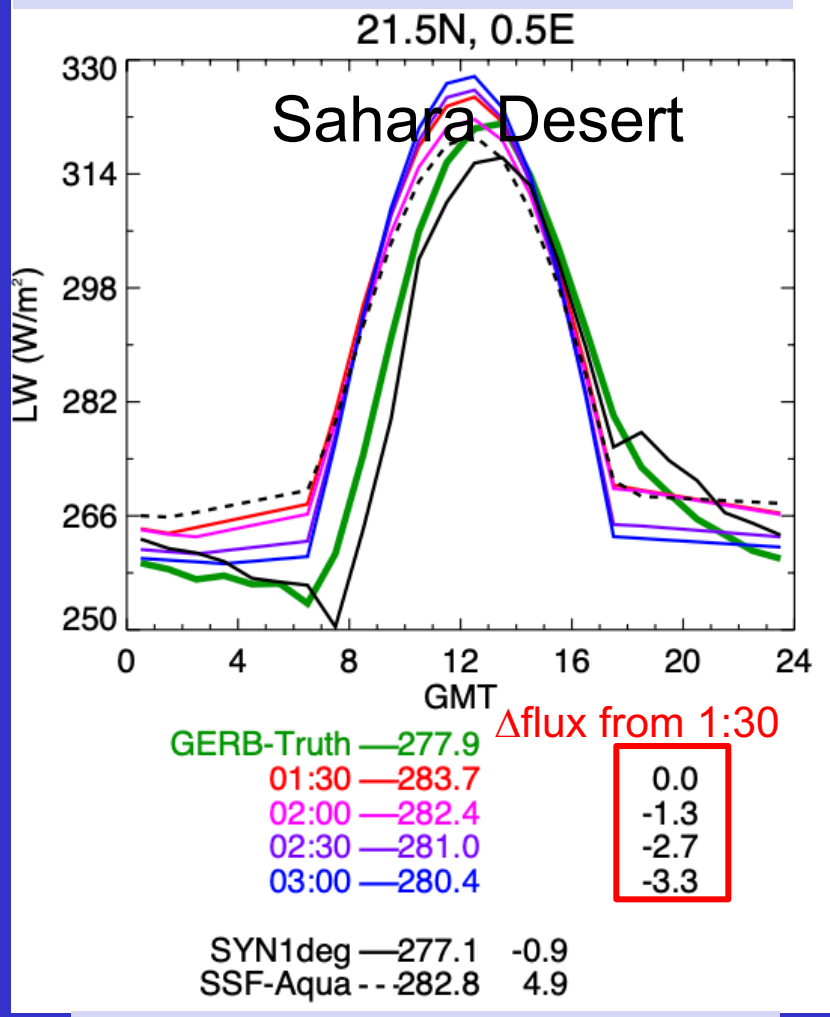
land convection starts before noon and peaks at sunset

Monthly Mean LW differences relative to Aqua (1:30), January 2010

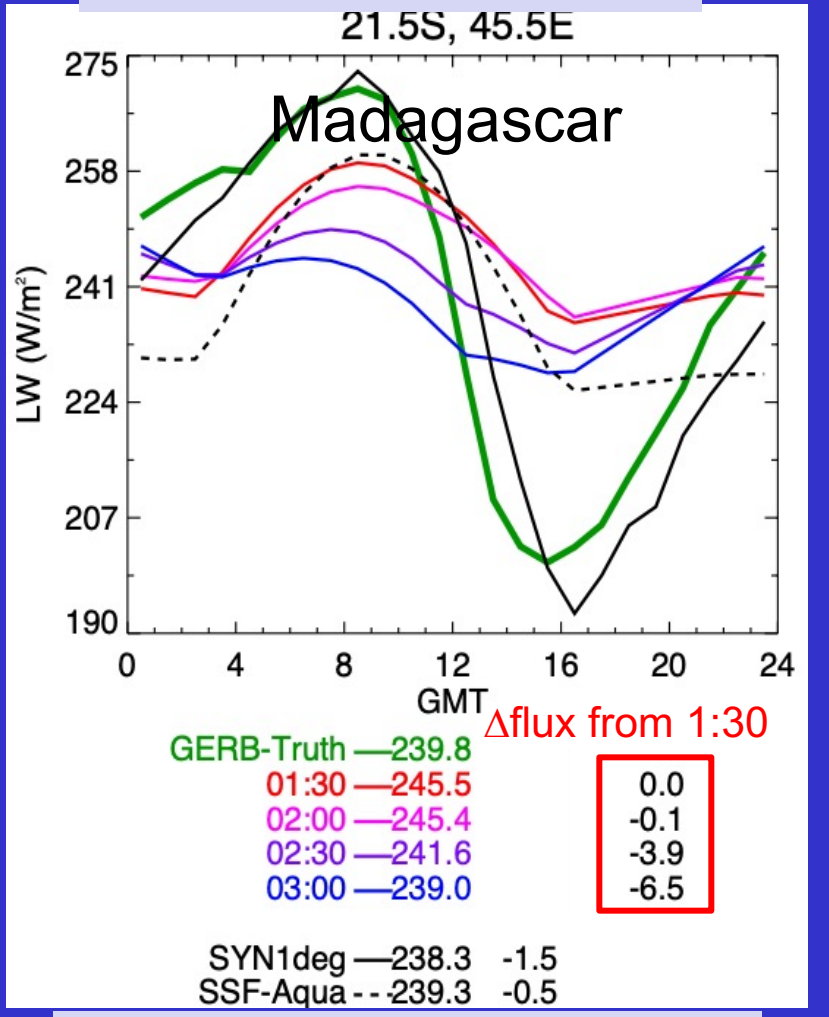
Maritime stratus peaks during morning



clear-sky desert symmetric about noon



Land afternoon convection



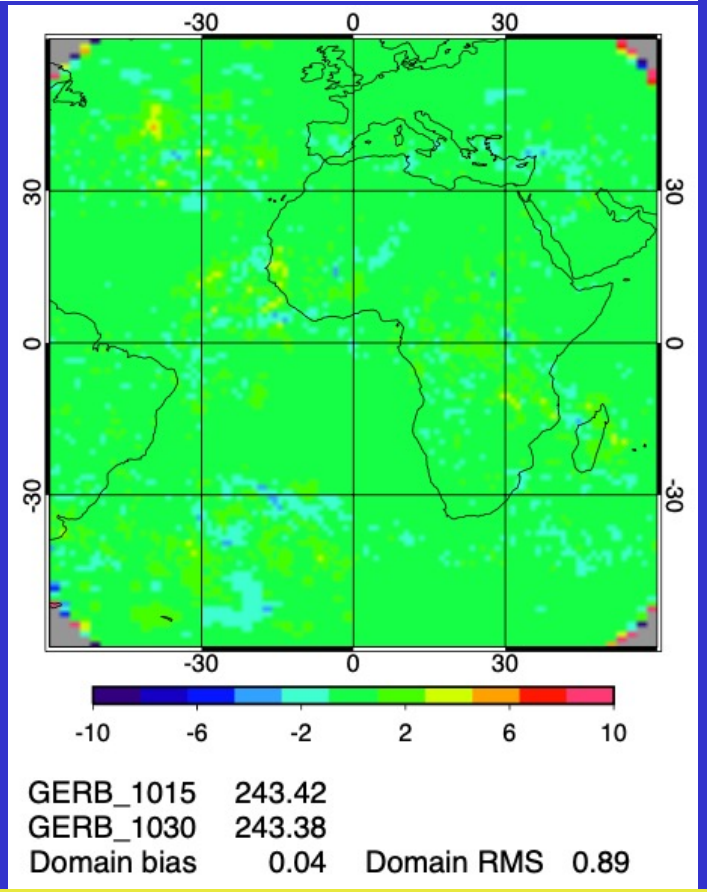
Linear interpolate LW flux observations to compute monthly mean

Employ half sine fit to estimate LW flux due to land heating and a constant nighttime flux

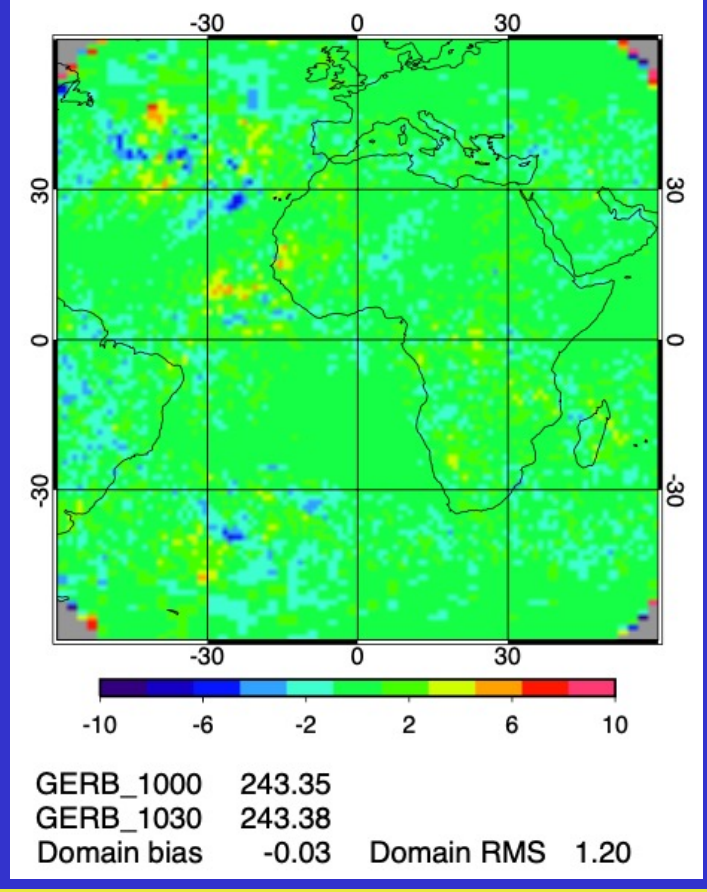
land convection starts before noon and peaks at sunset

Monthly LW flux difference relative to Terra (10:30), January 2010

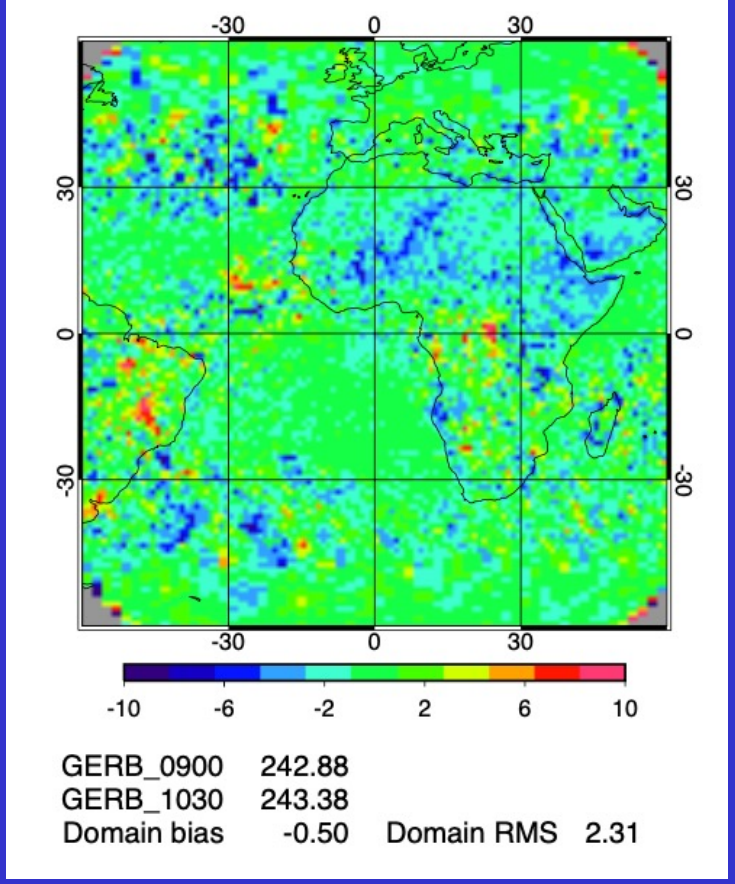
10:15-10:30



10:00-10:30

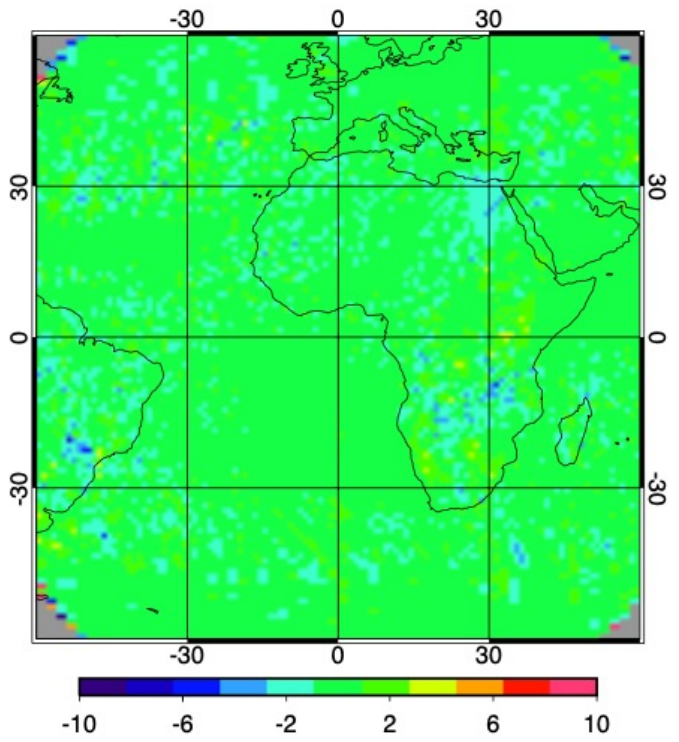


9:00-10:30



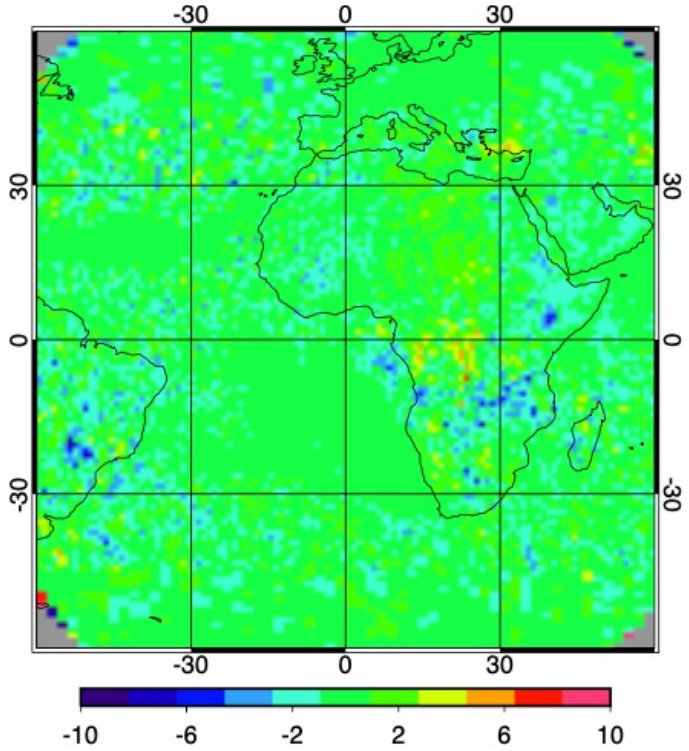
Monthly LW flux difference relative to Aqua (1:30), January 2010

1:45-1:30



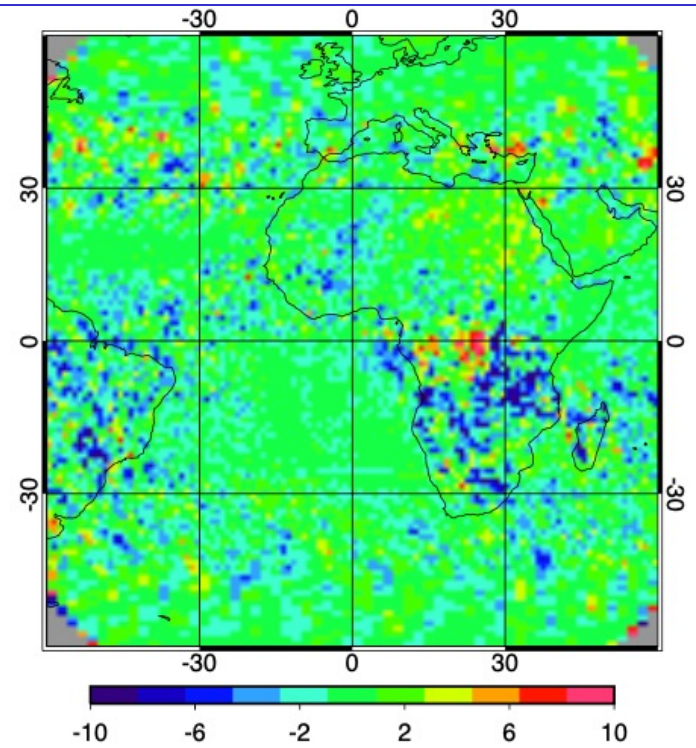
GERB_0145 243.13
GERB_0130 243.24
Domain bias -0.11 Domain RMS 0.88

2:00-1:30



GERB_0200 243.05
GERB_0130 243.24
Domain bias -0.20 Domain RMS 1.24

3:00-1:30



GERB_0300 242.74
GERB_0130 243.24
Domain bias -0.50 Domain RMS 2.38

Conclusions

- Terra 10:30AM & Aqua 1:30PM orbits have started to drifting towards the terminator.
- The MLTs drift will reach 15 min in September 2022 for Terra and mid-2023 for Aqua.
- GERB 15-minute resolution TOA fluxes are used to quantify the impact of the MLT changes on monthly regional SW and LW fluxes.
- We find a 15-minute drift can result in SW monthly regional flux changes of > 2 Wm^{-2}
- The new CERES EBAF product will transition from Terra&Aqua to NOAA-20-only (1:30) CERES observations in April 2022.
- CERES SYN1deg Ed4.1 will transition from Terra and Aqua to Terra and N20 in April 2022

CERES Edition 5 product improvements

CERES TISA products

- The single satellite SSF1deg product uses constant meteorology based on the satellite local equator crossing time to account for the regional diurnal cycle to compute the daily and monthly mean SW and LW fluxes
  - No expected Ed5 science improvements
- The Terra & Aqua & GEO SYN1deg product use 1-hourly GEO derived fluxes and clouds to account for the regional diurnal cycle
  - SYN1deg Ed4.2 GEO reprocessing to be released in early 2023
  - GEO SW NB to BB improvements
- EBAF, combines the temporal stability of the SSF1deg product and the diurnally complete SYN1deg product
  - Utilizes the SW diurnal models based on the GEO diurnal asymmetry factor and the SYN1deg LW fluxes
  - Norman and Seiji to provide EBAF Ed4.2 update
- FluxbyCldTyp product stratifies observed by PC-tau bins
  - Machine Learning improved subfootprint MODIS to BB fluxes

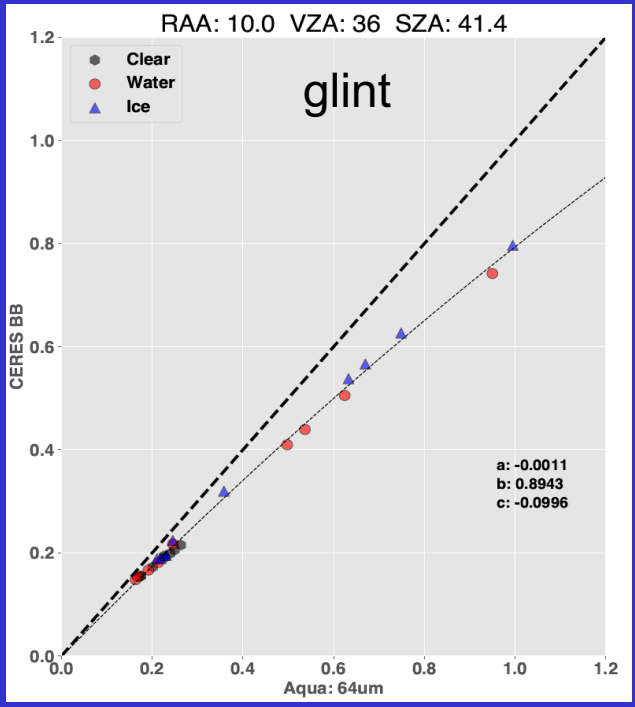
SYN1deg Ed4.2 product

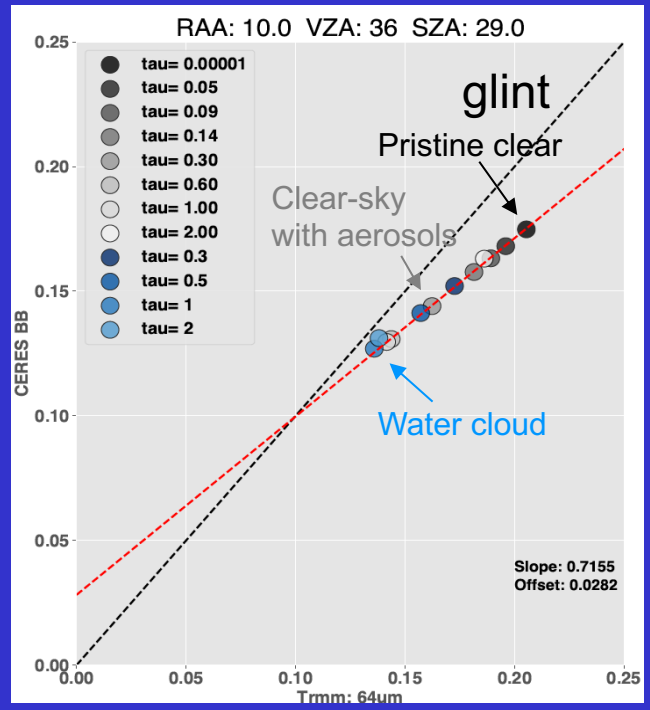
- GEO reprocessing of the entire (2000-2022) for greater computed flux and cloud consistency across the record
  - Met 8,9 and 10 reprocessed using the latest Met-11 code
  - GEO 2-channel satellites, reprocessed with improved cloud mask and night-time optical depths
    - GMS-5 Mar 2000 to Apr 2003
    - Met-5 57° Mar 2000 to Jan 2007
    - Met-7 0° Mar 2000 to Apr 2004
    - Met-7 63° Jan 2007 to Jan 2017
- The twilight cloud retrievals (SZA>60) to be temporally interpolated across the twilight hour-boxes
- Code bug fixes
- To be released in early 2023

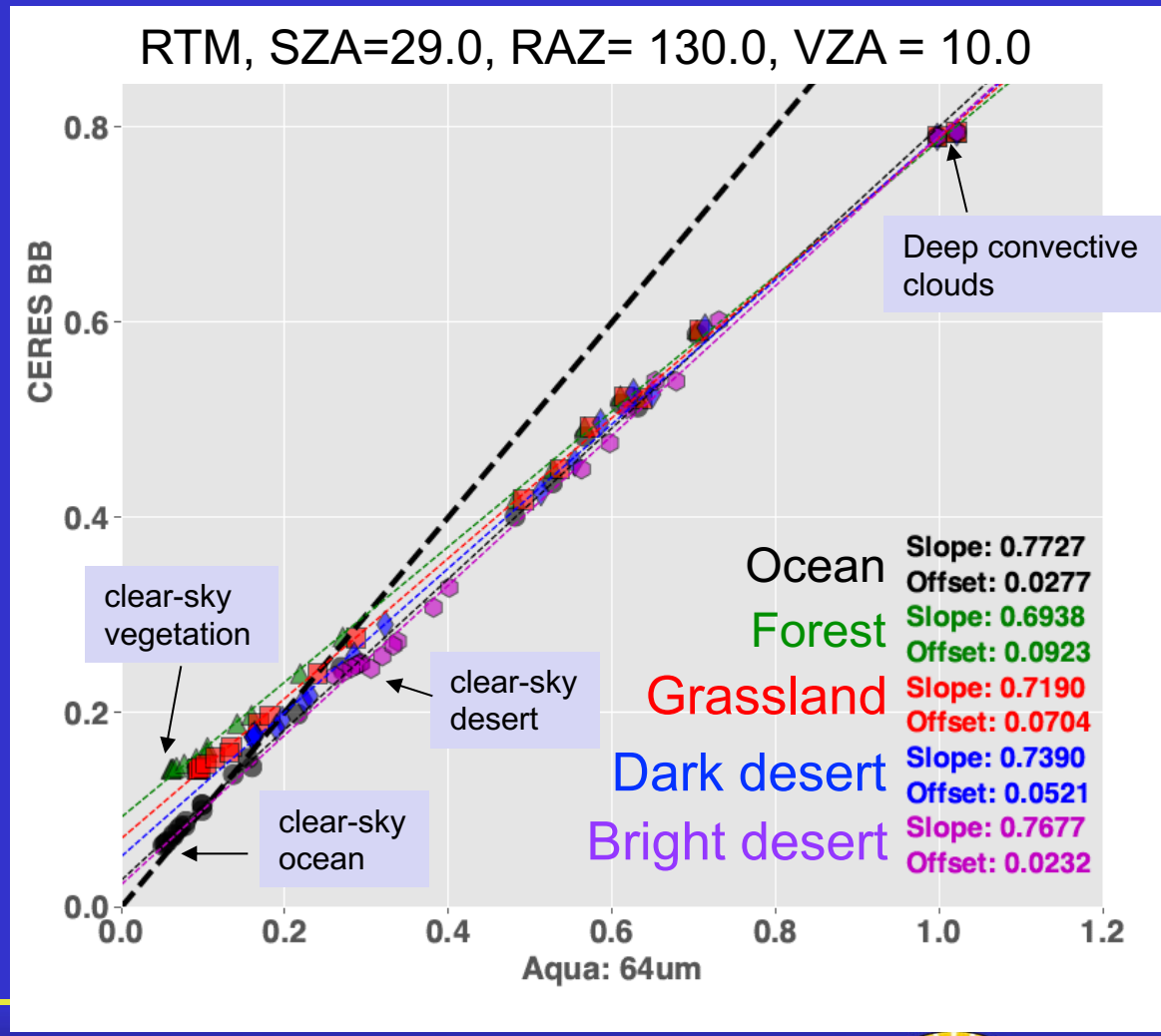
GEO SW NB to BB improvements

- Convert GEO visible narrowband (NB) channel directly to broadband (BB) radiance using hyper-spectral RTM, ~ 2500 wavelengths (0.2μm to 5μm)
  - Eliminate the Ed4 two step process of converting GEO to MODIS-like and then using empirical MODIS-like to BB radiance (Ed2 SW NB to BB LUT codes no longer exist)
  - Each GEO will have its own customized RTM LUT by convolving the RTM hyper-spectral radiances with the GEO spectral response function
  - For Land regions, use monthly imager 0.65/0.86μm ratio maps to account for changes in land surface albedo
- Continue to use the CERES TRMM ADMs to convert BB radiance to SW flux
  - TRMM orbit precesses and provides complete solar zenith angle sampling
- Continue to use the GEO Ed4 LW NB to BB based on MODIS/CERES observations for Ed5

SW NB to BB strategy





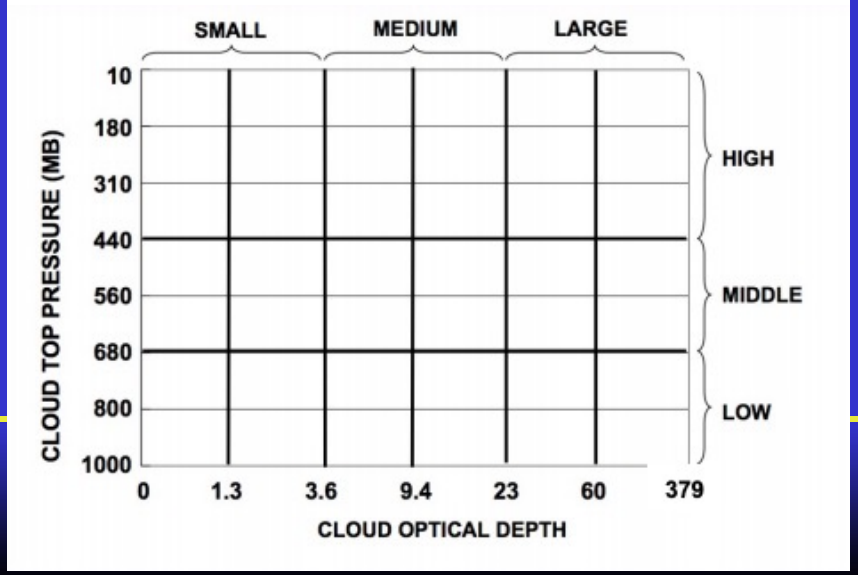


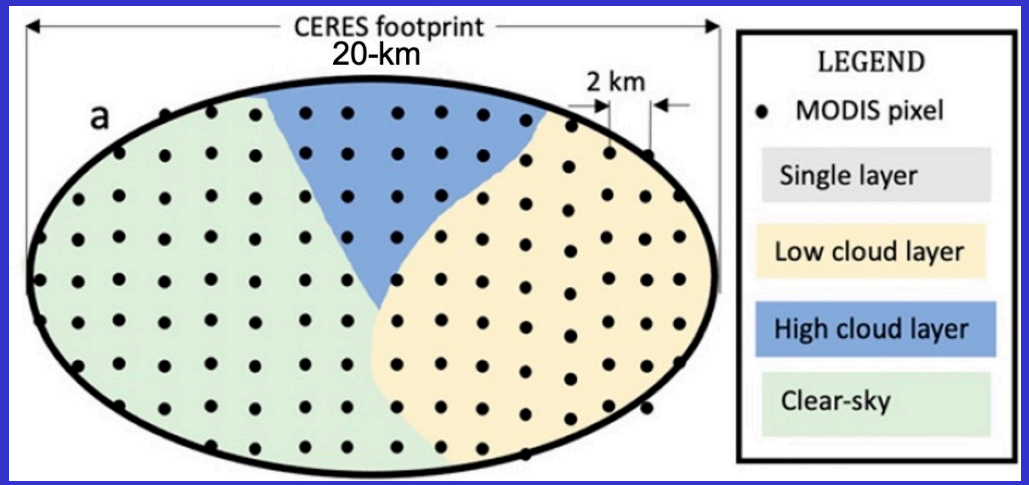
- For each angular bin the NB and BB reflectance pairs are regressed (all clear and cloud phases and optical depths
- Over land, the RTM surface BRDF and spectra are based on MODIS. Use observed 0.86μm/0.64μm MODIS ratio maps to account for vegetation NIR reflectance.

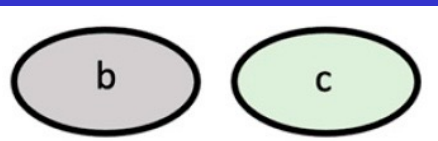
FBCT (FluxByCldTyp) product

- Terra+Aqua gridded daily and monthly averaged daytime (SZA<82, no nighttime or twilight) fluxes stratified by cloud top pressure and optical depth
- Compute BB fluxes for each of the 42 Pc-Tau cloud type bins
  - Compute BB fluxes for each sub-footprint area from empirical NB to BB coefficients based on single scene CERES footprints
  - Normalize the computed BB flux to the CERES observed flux at the footprint level

42 Pc-Tau cloud type bins







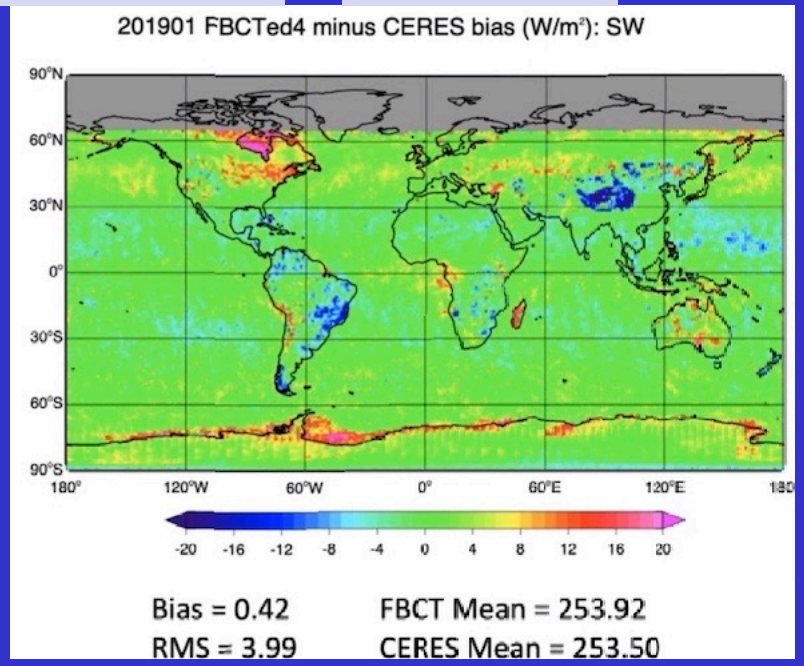
single scene footprints

Comparison of Ed5 FBCT ML algorithms with Ed4 SW

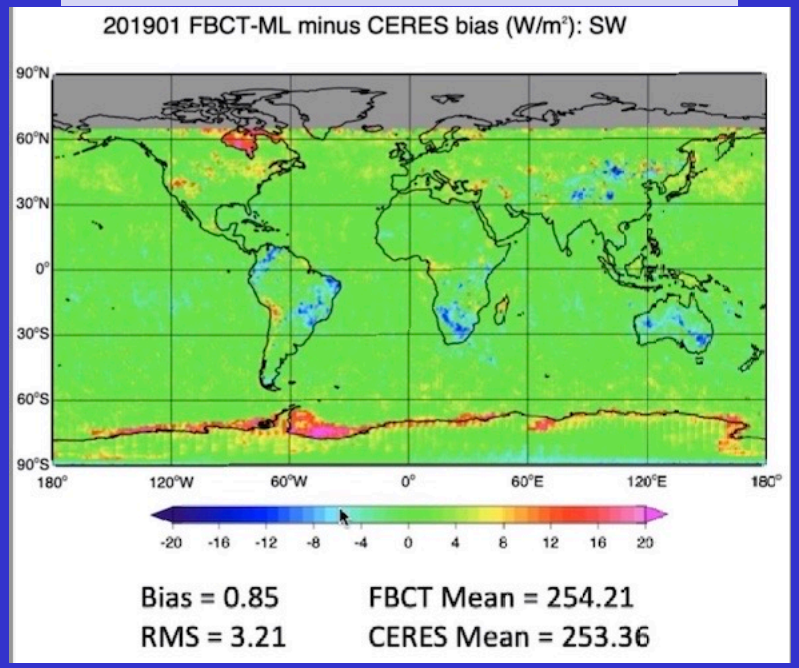
- Use ML to derive MODIS narrowband to broadband relationships rather than LUT
- Compare the aggregated subfootprint NB to BB fluxes with the observed footprint flux

Jan 2019

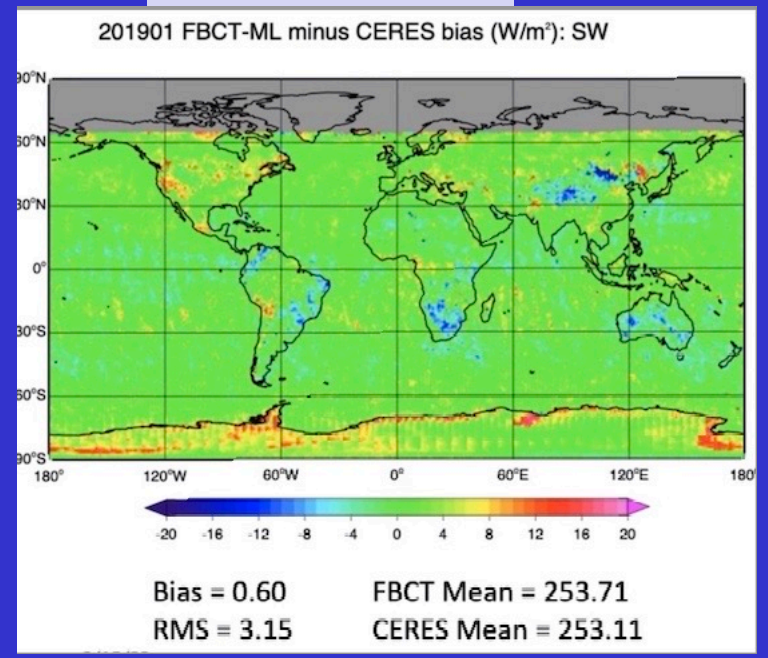
SW Ed4



SW ML radiance/ADM



SW ML flux

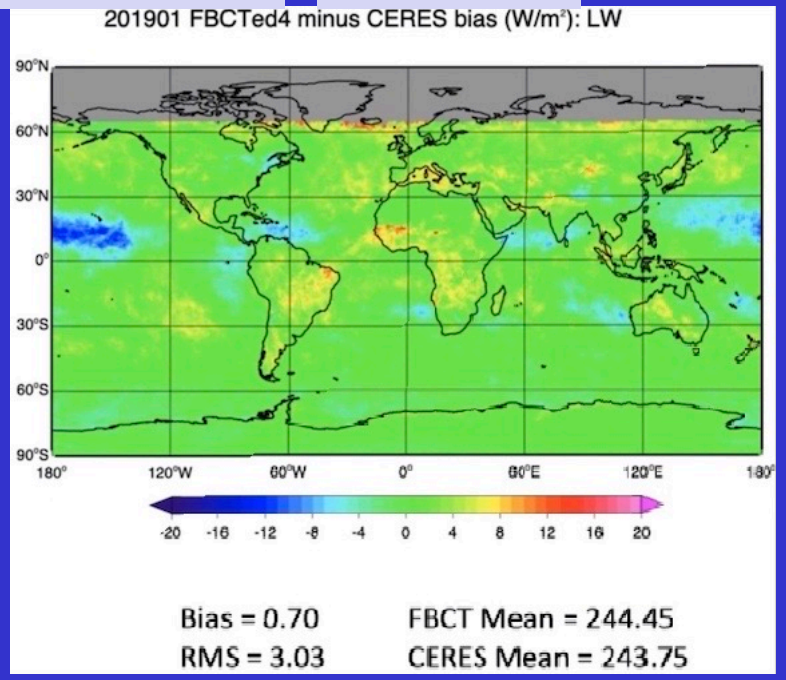


Use ML from 2007 to 2011 Januaries and apply to Jan 2019

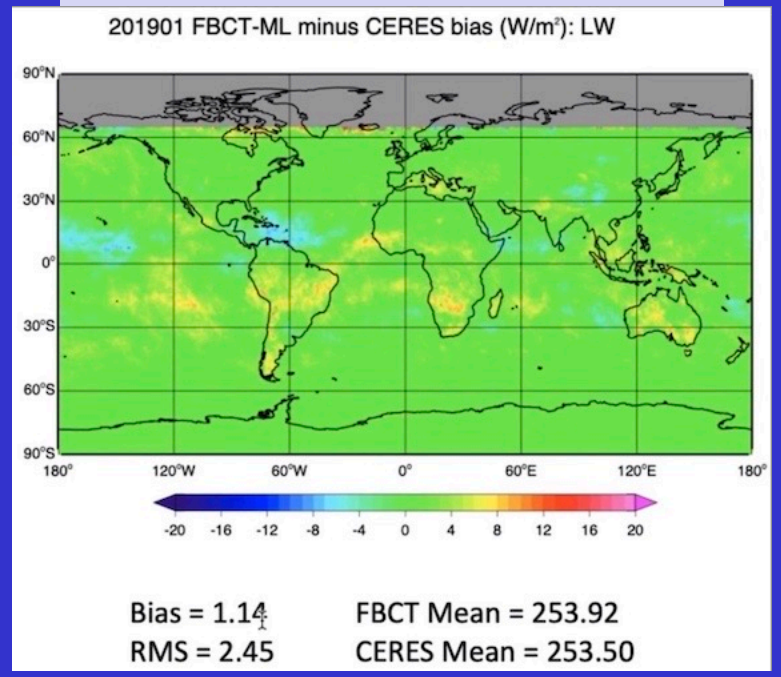
Comparison of Ed5 FBCT ML algorithms with Ed4 LW

- Take advantage of the 19 MODIS channels available to improve ML derived fluxes

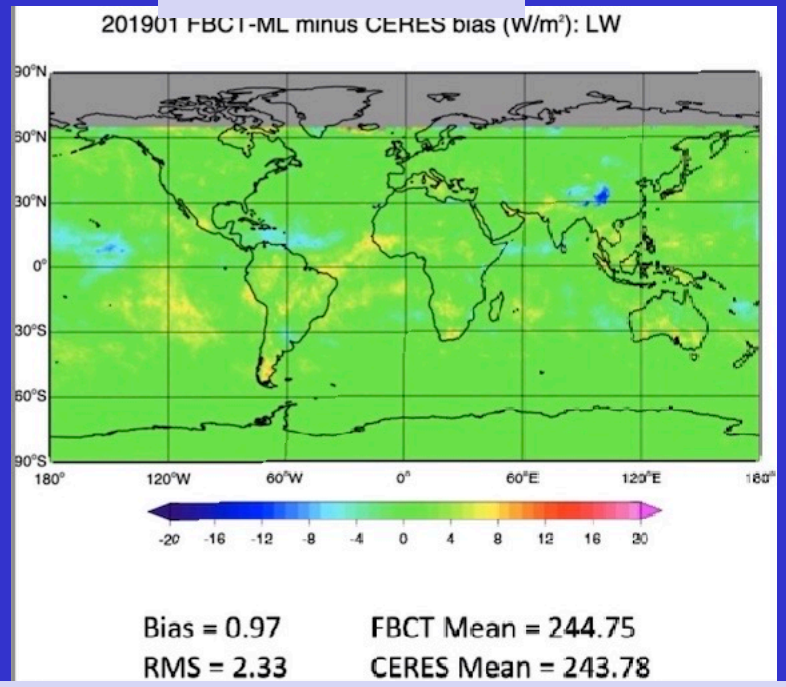
Jan 2019 LW Ed4



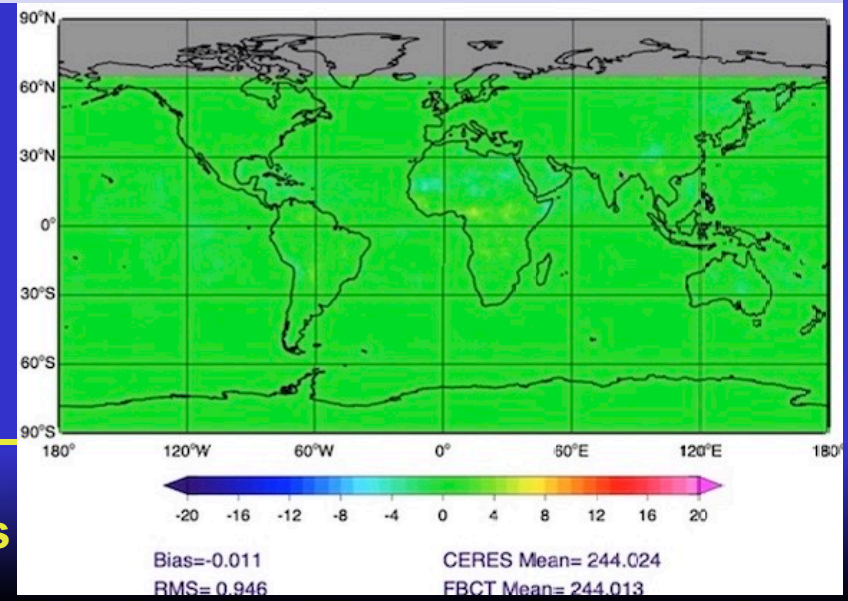
LW ML radiance/ADM



LW ML flux



Ed5, MLflux 6.7μm, 8.6μm, 11μm, 12μm, 13.3μm



What Can We Learn from Terra & Aqua MLT Changes?

- The Terra and Aqua MLTs will cross 9:00AM and 4:00PM, respectively, in 2026 if the missions are allowed to continue that long.
- Test of SSF1deg diurnal models over greater SZA
- Test of SYN1deg GEO/CERES 5x5 regional normalization and GEO SW/LW NB to BB algorithms
  - Do the GEO fluxes anchored to either Terra, Aqua or N20 provide similar hourly/daily fluxes?
- Perform GEO scan modes
  - Have the CERES instrument scan in the GEO line of sight similar to the GERB and CERES validation scans
  - Assess consistency of GEO imager-derived cloud properties and fluxes over a wide range of solar zenith angles everywhere between 60S-60N with MODIS cloud retrievals.